Section 2 - SITE DESCRIPTION

Site History

The evolution of the Maui Space Surveillance Site demonstrates several stages in the history of space object tracking telescopes. The oldest designs still in use are the 1.2 Meter dual telescopes and the 1.6 Meter telescope. A modern 3.6 Meter telescope, the Advanced Electro-Optical System (AEOS), is on line with various sensor packages under construction.

The designers of the Maui 1.2 Meter and 1.6 Meter telescopes selected the German style equatorial mount. Placing them on azimuth turntables provided a third axis to enable easier tracking of objects that orbit in planes other than the Earth's equatorial plane. Sensors that detect light collected by these telescopes are mounted on the telescope body itself and must be remotely controlled.

The Laser Beam Director (LBD) was developed to illuminate and image dark sky objects. The LBD is a semi-fixed 0.6 Meter aperture beam expander telescope looking into a tracking flat. Heavy equipment, such as the multi-stage Korad ruby laser, resides in a room below next to the concrete pier that supports the telescope. The tracking flat swings through its range of motions unencumbered by instruments and cables.

The most recent addition to AMOS' large optical systems is the 0.8 Meter Beam Director Tracker (BD/T). This is an afocal beam expander on an elevation over elevation mount, using mirrors to relay the beam through large hollow bearings and out to the laser rooms on either side of the telescope mounting pier. There are two telescope mirrors in the standard afocal pattern plus six optical flat mirrors. Three flats are hidden within the structure of the telescope. No major instrumentation hangs on this telescope frame. The unencumbered frame pivots in an elongated gimbal having a hollow box-like structure containing the hidden mirror mounts. This gimbal-box pivots at each end. The two sets of pivots allow the telescope access to most of the sky, except for east and west azimuths, where the lowest elevations are about 30^{o} due to a GEODSS dome to the east and the gimbal bearing to the west.

The current AEOS 3.6 meter telescope is a yoke and azimuth bearing. The major instrumentation will reside in laboratories located several floors below the telescope. The optical path will descend vertically through the center of the azimuth bearing after passing through one side of the elevation bearing, reflecting downward and then inward to the azimuth axis.

Site Characteristics

The observatory (referenced to the point on the azimuth axis at the height of the intersection of the polar and declination axes of the 1.2 Meter telescope mount) is located at a geodetic altitude of 3058.2 meters, close to the crest of the dormant volcano Haleakala at:

- latitude 20:42:30.5 degrees N
- longitude 156:15:28.7 degrees W

This site provides a relatively stable climate of dry air characterized by low levels of particulate matter and minimal scattered light from surface sources. The astronomical seeing for the site reflects the exceptional nature of the location. Based on double star observations, seeing is typically on the order of one arc second. Measurements of Fried's atmospheric turbulence coherence length, (r_o), exclusive of "dome seeing" (phase shifts due to internal and external temperature differences), indicate a 12 cm average value during the summer, with winter values averaging 10 cm. A program is currently underway to significantly reduce dome seeing effects.

Weather and Atmospheric Statistics

The weather on Maui is dominated by northeasterly trade winds of 10-25 mph. Trade winds are generated by a series of high pressure anticyclones and ridges which persist 300-500 miles north of the islands. A trade wind inversion normally traps marine moisture and haze well below the site, so the MSSS is characterized by dry, clear air with visibility exceeding 150 km.

From late November through April the highs and their associated ridges periodically break down or are pushed south by low pressure systems moving through the North Pacific toward the North American mainland. Fronts and troughs associated with these lows are primarily responsible for Maui's rainy season. Another component of the rainy season is the "Kona" (Hawaiian for leeward side) storm, generated when high pressure centers move south of the islands and the winds turn southerly bringing moisture north from the subtropical convergence zone. From July through October, occasional rain and storms are associated with the remnants of hurricanes and tropical storms originating off southern Mexico. These storms typically dissipate to the east of Maui, but a hurricane actually reaches the islands every 5-10 years. Average rainfall at the site is about 15 cm/month during winter and spring (November-April) and about 5 cm/month in the summer and fall (May-October). Light snowfall occurs at the site 2-3 times each winter with maximum accretions of 7 inches observed.

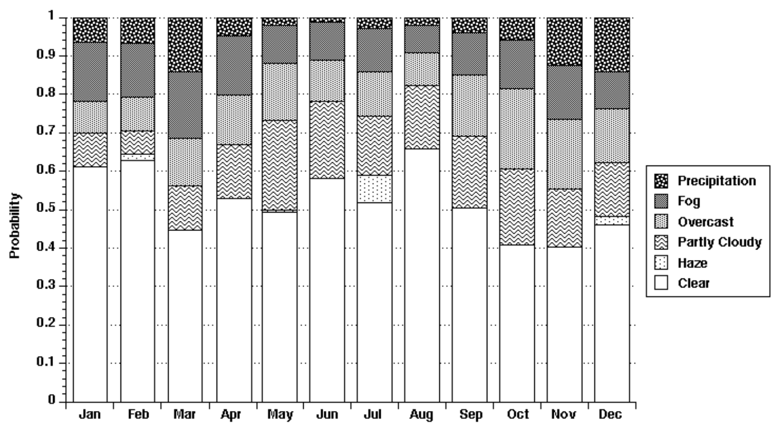

Figure 2-1, AMOS Weather Observations, 5-yr Average

Summary of Weather Observations

Figure 2-1 shows a summary of site weather observations over the period 1986 through 1991. These observations are for the dusk-to-dawn observational time. The site does not operate under precipitation, fog, or overcast (>80% sky cover) conditions. The domes are also closed when wind speeds exceed 35 mph. The combination of these factors produces a monthly average of 60% operational time in winter and spring and 70% during summer and fall. Clear weather in the figure refers to spectroscopic sky quality. Photometric sky quality data are not currently available.

Temperature

Figure 2-2 shows the average monthly temperature at the MSSS along with the average and extreme monthly highs and lows for the 1984-1991 period. The four year average diurnal temperature swing is 5.8o Celsius with an afternoon high at 2-4 PM and an early morning low at 5-7 am, HST. The average site relative humidity is about 45%. A frequent afternoon peak in relative humidity results from anabatic winds that carry moisture upslope from below the tradewind inversion. These winds subside and the relative humidity drops quickly as dusk approaches. Extended periods of 5-20% relative humidity are not uncommon. This, combined with the 710 mbar average barometric pressure, should be considered in the design of electronic equipment for use at the site.

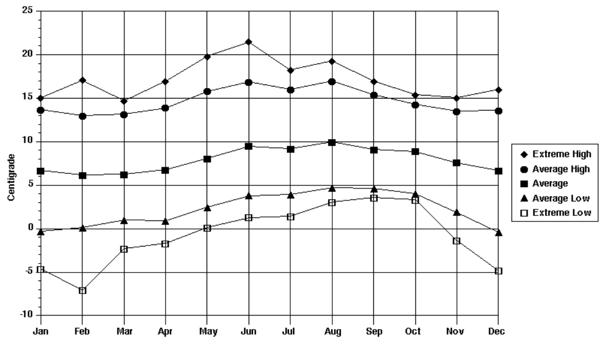

Figure 2-2, AMOS Monthly Temp, 5 yr. Average

Wind Speed Information

Figure 2-3 shows the monthly average, maximum hourly average, and peak wind speed for the site and Figure 2-4 shows the average monthly wind direction. While most periods of high winds occur during winter storms, winds over 50 mph can occur at any time.

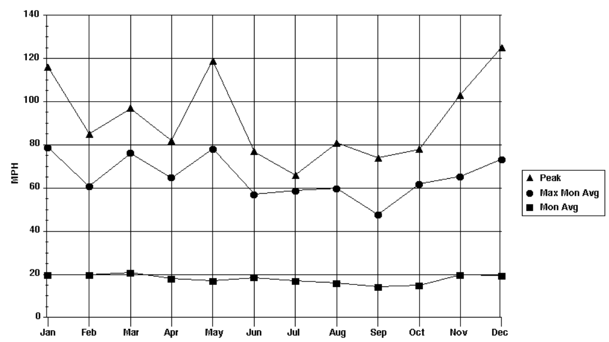

Figure 2-3, AMOS Windspeed, 5 yr. Average

Seeing

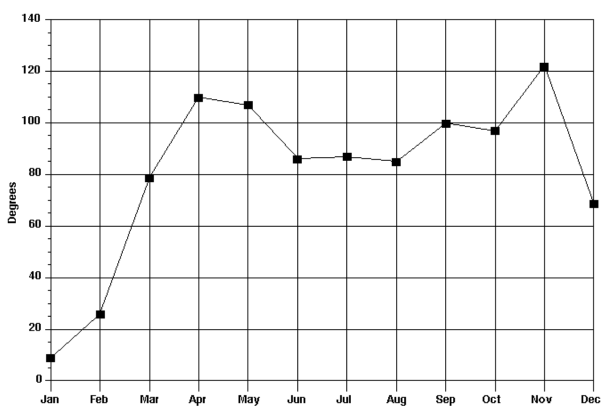

Figure 2-4, AMOS Wind Direction, 5 yr. Average

Seeing data is derived from stellar image size measurements on both the 1.6 Meter and 1.2 Meter telescopes. The average effective zenith r_0 at a wavelength of 500 nm for the 1.6 Meter system is about 6 cm in the winter and 7 cm in the summer. The 1.2 Meter seeing averages about 8 cm with a slight peak in June. Recent measurements suggest that the difference in effective r_0 for the two systems is largely due to differences in dome seeing degradation. Exclusive of dome seeing, the site can produce averages of about 10 cm in the winter and 12 cm in the summer. A program is currently underway to reduce the dome seeing effects. More detailed atmospheric data is available on request.

Atmospherics Instrumentation

Meteorological data is collected and archived at 3 minute intervals 24 hours/day. Standard data include wind speed and direction (two sensors), temperature, dew point, and barometric pressure. A visibility monitor was added to the suite of instruments in the winter of 1992. Specialized sensors include a stellar scintillometer used to derive CN2 as a function of altitude from site level to above the tropopause. Seeing measurements also can be obtained from stellar image size measurements on the other telescope systems. The site is equipped with an upper air sounding (radiosonde) system that can provide temperature, relative humidity, and barometric pressure as a function of altitude to the 80,000-100,000 foot level. More information about atmospheric instrumentation is available.

Observatory Facilities

The MSSS consists of a main building interconnecting the two large domes (east and west) and two small domes (north and south), three GEODSS domes, and a separate technical support building. The main building includes office and work spaces, an operations control and computer facility, a secure communications facility, optical and electronics laboratories, a briefing room, and kitchen facilities. The east dome contains a 1.6 Meter diameter aperture telescope while the west dome houses two 1.2 Meter diameter telescopes on a common mount. The south dome contains the 0.6 Meter Laser Beam Director (LBD) and the north dome houses the 0.8 Meter Beam Director/Tracker (BD/T). Figure 2-5 shows a three-dimensional layout of the observatory. Telescopes are described in another chapter of this manual.

The technical support building provides a mirror coating facility, an electronics calibration laboratory, and a fully equipped machine shop, and includes more office space. Additional support equipment includes a 1.6 Meter diameter optical flat, a water collection system, and a laser cooling system.

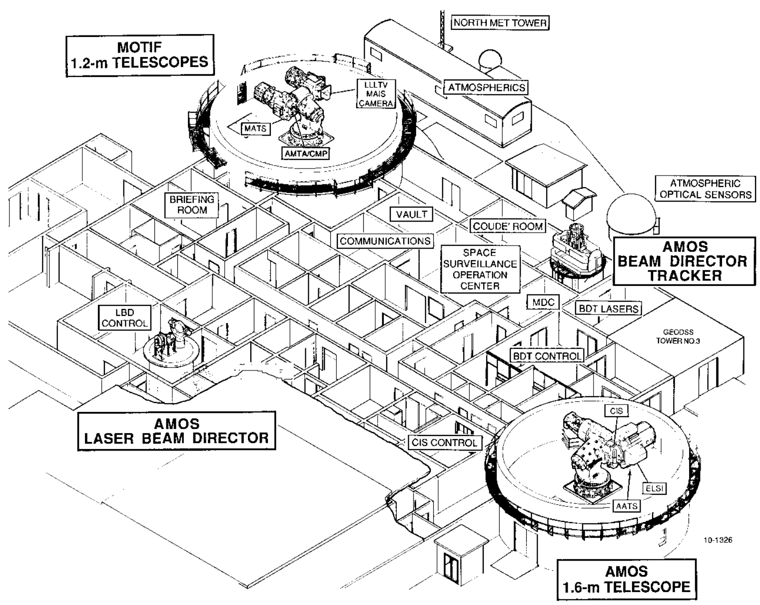

Figure 2-5, AMOS/MSSS Site Layout

Endoatmospheric Studies

Ideally situated for full scale endoatmospheric studies with aircraft, drones, and cooperative instrumented aircraft test beds, the site has direct visual access into over 30,000 square miles of Special Operating Areas (SOAs).

SOA assignment and use is coordinated by AMOS for the VE with the controlling agency, the U.S. Navy Fleet Area Control and Surveillance Facility (FACSFAC), located on Ford Island, in Pearl Harbor, Oahu. In practice, the SOAs are reserved for specified periods for either shared or exclusive use, depending on test constraints and military training requirements, and can be extended through special agreements with the FAA to approximately twice their areal extent to encompass tests requiring very long path (up to 300 miles) observations. Cooperative aircraft are typically controlled directly by AMOS personnel after they enter the SOA via two installed (primary and backup) 20 watt AN/GRC-171 UHF radios, which provide two-way communications with participating aircrews out to a useful reception range of ~250 nautical miles.

Sources of Aircraft Targets

Owing to the proximity of MSSS to several Hawaiian area aircraft operating bases and training ranges, a wide variety of fixed and rotary wing tactical and support aircraft can be routinely accessed for cooperative and non-cooperative experiments. Services can be obtained at no cost in most cases, if it can be demonstrated that test requirements, flight profiles, etc. are relevant to unit training goals of the participating aircraft operating units.

Measurement Scenarios

The suitability of the site for endoatmospheric studies derives from its unique location and support infrastructure for electro-optical surveillance. Applying well documented and verified scaling laws, valid tests and measurements can be supported in thermal imaging, atmospheric transmittance, clutter phenomenology including detection, and sensor performance evaluation. A broad range of challenging test requirements involving advanced simulations in these areas can be satisfied with a suite of active and passive radiometric and imaging sensors which can be brought to bear on low elevation targets; or alternately, can host a VE-supplied sensor or system within the observatory complex (providing power, water, communications, engineering assistance, and shelter), or at selected remote field test sites on the mountain.

Field Office

Management, administration including security, planning, certain data reduction and analysis tasks, engineering, drafting, software development, microprocessor and digital development, and most logistic functions are performed in a field office facility located 80 feet above sea-level near the town of Kihei. The AMOS/MOTIF field office is a 20 minute drive from the Kahului Airport and approximately 49 miles (80-90 minutes) from the summit of Haleakala. Meetings with visitors, potential users, and other interested groups can be held in the conference room. Such meetings may be enhanced by teleconferencing, available between the field station and the observatory by microwave link. Figure 2-6 Is a map showing the route from the airport to the AMOS/MOTIF Field Office.

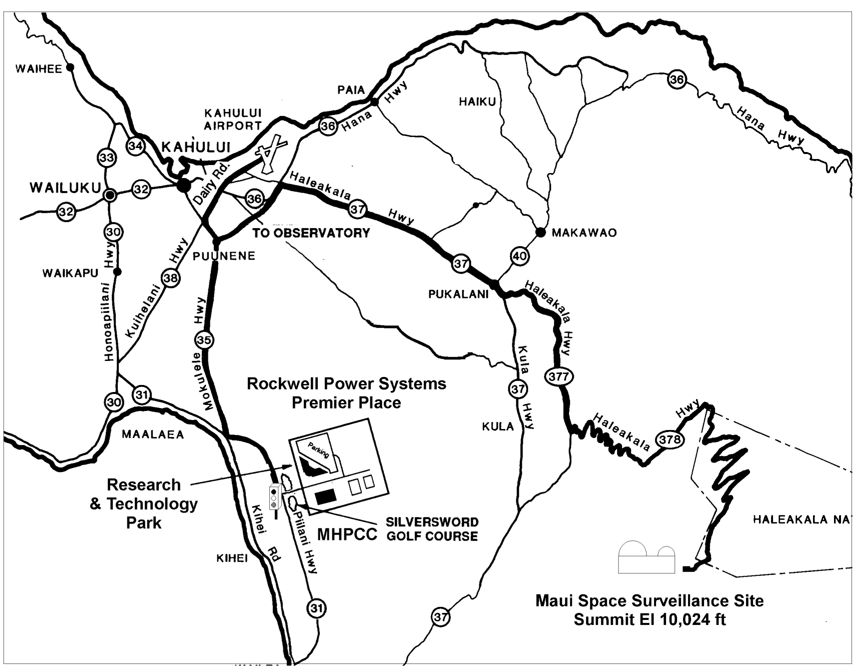

Figure 2-6, AMOS Site Map